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Implementation of a Risk Management Program to Address Public Policy Issues in Mega Projects

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Professor Andrew Bates is an experienced senior construction manager with a proven ability to plan, direct and complete construction and engineering projects safely, on time and within budget. His ability to communicate, motivate people and devise successful action plans in both small and large organizations has allowed him to thrive in high stress, fast-paced work environments requiring multi-tasking and immediate decision making skills. Since 2009, Mr. Bates has been passing his knowledge and experience onto students in the Civil Engineering Department at Polytechnic Institute of New York University in subject areas of Strategic Planning, Infrastructure Planning, Construction Planning, Risk Analysis and Risk Management. Prior to joining the faculty at NYU Poly, he was a Professor at the United States Air Force Academy in Colorado Springs where he taught Introduction to Engineering, Air Base Design and Performance, Construction Project Management, Project Management and Contract Administration and Software Applications for Civil Engineers. During his four years there, he was the Deputy for Plans and Programs and the Construction Division Chief for the Department of Civil and Environmental Engineering. As a retired U.S. Air Force Major, Mr. Bates has compiled an impressive leadership portfolio which includes many achievements. As the Deputy of Plans and Programs at the Air Force Academy he was responsible for long range planning and budget issues for the Academy's Civil and Environmental Engineering Department. He also worked directly for the Dean of the Faculty as an Owner's Representative on three $15M phases on the 1.2M SF academic building renovations. During those renovations he submitted change orders on the end-users' behalf to correct design omissions and errors as well as incorporate changes resulting from changes to end-user mission requirements, he monitored construction schedules and continually communicated progress to all appropriate stakeholders, and designed a construction lay down area with the Army Corps of Engineers and the contractor and coordinated alternative traffic flow with emergency response and facility personnel.

Mr. Bates' career in the Air Force provided experience with several Department of Defense construction projects where he was able to refine his leadership and construction management skills. He planned, resourced, and executed the design-build of over thirty construction projects involving airfield pavements, base facilities, maintenance and repair ranging from $25K to $180M. He wrote project statements of work, performed periodic design reviews, developed feasibility reports, schedule updates, executed the change-order process, and validated progress payments. He also conducted inspections to ensure zero violations of environmental and OSHA standards. All of these projects required refinements of the skills he acquired while completing his B.S. in Civil Engineering at the USAF Academy and his M.S. in Civil Engineering at the University of Colorado in Boulder

Implementation of a Risk Management Program to Address Public Policy Issues in Mega Projects

Abstract

Discussing risk raises a variety of questions. What is risk? Why have so many types of risk developed? How are the quantitative modeling aspects of risk used to communicate risk information as well as the opinions and judgments of the evaluators? In the end, the more fundamental question is why do we perform risk analysis at all?

As an advanced economy and developed nation, the US has addressed risk in many areas, primarily in insurance and more recently in the financial industry. Now the concept of risk is being extended into physical infrastructure projects and transportation in particular. Clearly this extension is due to the complexity of today's megaprojects. These projects are planned and built based on enormous quantities of data and information. The reality that not all data is of the same quality and often the planning is insufficient.

What is driving this? What are the expectations of the stakeholders? After all, they are allocating resources into this effort with some expectation of a return. The value received from performing a risk analysis offers advantages over proceeding blindly thru the fog without the benefit of a "risk radar." Why spend the effort to analyze past experience and apply these lessons learned in a systemic manner to the current project? Is this something that we do intuitively? Is another engineering management discipline needed that will invariably lead to more work?

In reality, there are limits to our abilities to deliver projects using strictly intuitive methods. Engineers do not develop systems in their heads or produce theories on the backs of napkins. Engineers develop formalized methods and models to take advantage of their creativity, analytical abilities and learn from past failures. This developmental approach allows society to allocate precious resources with a greater sense of confidence that the project will meet expectations for the resources committed. At a more elemental level our society has evolved where given the choices to commit resources, professional managers are expected to deliver. The expectation means the project performs as promised, safely, with no harm to any humans or the environment, within budget and on schedule. Meeting these expectations is better achieved when a risk analysis is performed on the project.

Risk is identifiable as part of a disciplined practice. Conducting a thorough risk analysis can communicate the complexity and associated uncertainties more effectively. In the context of project delivery for infrastructure projects, the entire risk management process can outperform any intuitive project execution method.

This paper will address the need for developing a data driven, formal risk engineering program. More than that, this paper will present and discuss options for understanding the often unarticulated business model that underlays some contemporary risk practices within the current public policy framework. The objective of this paper is to familiarize the reader to develop their own framework of a transition as well as attributes. In the end, the value of risk engineering as presented in this paper is the ability to offer better project performance in terms of meeting project objectives. A current graduate level course uses these principles to teach risk analysis as part of a risk engineering program.

Introduction (Prelude to Risk /The Challenges of defining Risk)

The project manager's ultimate responsibility is to deliver an effectively and efficiently executed project to stakeholders and funding partners. It is common practice for public agencies to discharge responsibility to the public policy makers (legislative or executive) to ensure the agency and project organization possesses;

> *"(The) management capacity and capability necessary to carry out a project efficiently, and effectively; the effectiveness of the sponsor's project delivery…and ensuring that … management processes are based on sound decision making, driven by a thorough understanding and implementation of well documented, risk-informed project management practices."* [i]

Establishing the foundation and supporting a rigorous discussion of risk and all its related applications for various audiences in public works projects, requires establishing basic concepts, application contexts and analysis frameworks. It also provides the opportunity to establish the risk analysis and management knowledge as an engineering discipline using analogies from other engineering disciplines such as structures or hydrology.

The American Society of Civil Engineers recognized the importance of risk when it stated:

"The manner in which civil engineering is practiced must change. That change is necessitated by such forces as globalization, sustainability requirements, emerging technology, and increased complexity with the corresponding need to identify, define, and solve problems at the boundaries of traditional disciplines. As always within the civil engineering profession, change must be accomplished mindful of the profession's primary concern for protecting public safety, health, and welfare."[ii]

In general, risk is understood in a variety of ways. One may be interested in estimating fatalities on a highway, or the precipitation quantity from a 100 year storm, or the magnitude and frequency of earthquakes in a specific region. These are all good and useful exercises, however, the goal of this paper is to:

1. Define "risk engineering" as an integrating discipline that supports design development, project controls and project management.
2. Develop a theoretical foundation for the economics of risk, specifically the development of a rigorous theory of risk in economic terms and suitable for engineering applications in public works and infrastructure projects.
3. Lay the conceptual foundation for risk as an engineering discipline that can be integrated into an educational curriculum using the same building block approach found in other engineering subjects such as structures or hydrology.
4. Understand the role of risk engineering in supporting policy makers or critical decisions for infrastructure projects as well as providing regulatory or programmatic inputs that help in shaping that policy development.

1. Defining Risk Engineering

Aside from usage in the finance and insurance industry[iii], "Risk Engineering" remains undefined. However, both *risk* and *engineering* have well established definitions as described below.

The Department of Defense (DOD) Risk Management guide[iv] in Section one defines risk as: "…a measure of future uncertainties in achieving program performance goals and objectives within defined cost, schedule and performance constraints." What are noteworthy of the DOD definition are its core concepts of:

- "**Measure of risk**" as developed elsewhere, any statement on risk reflects the speaker's knowledge of risk in general and in particular on this project, expressed in either a qualitative or quantitative terms that may change over time as the project is defined, procured, or implemented.
- "**Future uncertainties**" are also a very specific DOD practice. Uncertainty may be associated with project planning elements such as deliverables, or actions taken in the past such as geotechnical borings. The underlying concept for the DOD is that this has validity in that their concept of risk visualizes a continuum running from high degree of uncertainty, or low likelihood of an impact to a high likelihood of an impact or a crisis. The other observation is the more granular concept of uncertainties as a broad class of variation in stakeholders versus the variation in project definition documents, contracting objectives versus as-negotiated, as-built, tested start up functionality.

- "**Achieving program performance goals and objectives**" is very good as a generic statement, but consider an alternative for infrastructure projects as delivering the specific project's performance goals and objectives.
- "**Defined cost, schedule and performance constraints**" A pivotal concept in this component is the reference to the word "constraint". The discussion of normative versus descriptive develops where the approved management budgets or baselines become synonymous with defined cost constraint as a "normative" constraint versus a description of an ad hoc constraint that may or may not be controlled or approved by a project management office becomes a "descriptive" constraint.
- **Performance must be linked to Constraints** This must be understood as requiring the project to be delivered WITHIN defined constraints. This is the capstone statement.

The Department of Energy (DOE) Risk Management guide[v] defines risk as: "…a measure of the potential inability to achieve overall project objectives within defined cost, schedule, and technical constraints."

The Department of Homeland Security defines risk[vi] as: "(the) potential for an unwanted outcome resulting from an incident, event, or occurrence, as determined by its likelihood and the associated consequences."

The Transportation Review Board (TRB) produced report for Federal Highway Administration (FHWA) on risk management and defined risk[vii] as: "An uncertain event or condition that, if it occurs, has a negative or positive effect on a project's objectives."

The Project Management Institute (PMI) in its Body of Knowledge document defines risk[viii] as: "Project risk is an uncertain event or condition that, if it occurs, has a positive or a negative effect on at least one project objective, such as time, cost, scope, or quality (i.e., where the project time objective is to deliver in accordance with the agreed-upon schedule; where the project cost objective is to deliver within the agreed-upon cost; etc.)."

The International Standards Organization (ISO)/American National Standards institute (ANSI) defines risk[ix] as: *"Risk (is defined as the) effect of uncertainty on objectives [ISO Guide 73:2009, definition 1.1] ISO notes its guide that …" Uncertainty is the state, even partial, of deficiency of information related to, understanding or knowledge of an event, its consequence, or likelihood"… while an effect is a …"deviation from the expected — positive and/or negative" and can occur at … "different levels (such as strategic, organization-wide, project, product and process)"….*

The Society for Risk Analysis defines risk as: "the potential for realization of unwanted, adverse consequences to human life, health, property, or the environment; estimation of risk is usually based on the expected value of the conditional probability of the event occurring times the consequence of the event given that it has occurred."

The American Engineers' Council for Professional Development (ECPD) has defined engineering as: "The creative application of scientific principles to design or develop structures, machines, apparatus, or manufacturing processes, or works utilizing them singly or in combination; or to construct or operate the same with full cognizance of their design; or to forecast their behavior under specific operating conditions; all as respects an intended function, economics of operation or safety to life and property."

The American Society for Civil Engineering (ASCE) defined civil engineering as: "…the profession in which a knowledge of the mathematical and physical sciences gained by study, experience, and practice is applied with judgment to develop ways to utilize, economically, the materials and forces of nature for the progressive well-being of humanity in creating, improving and protecting the environment, in providing facilities for community living, industry and transportation, and in providing structures for the use of humanity."[x] Although the document discusses risk as an aspect of civil engineering it fails to lay a basis for it in the definition. It also needs to reflect the role plays in project execution such as discussed above in the DOD risk definition. Reworking the ASCE definition to reflect this risk mission could be restated as follows: "…the profession in which a knowledge of the mathematical, ***statistical*** and physical sciences gained by study, experience, and practice is applied with judgment ***in the face of inherent uncertainties and incomplete information*** to develop ways ***in the form of products, deliverables and reports*** to utilize, economically, the materials and forces of nature for the progressive well-being of humanity in creating, improving and protecting the environment, in providing facilities for community living, industry and transportation, and in providing structures for the use of humanity, ***within defined constraints of scope, budget and schedule***."

Combining the last two paragraphs yields a working definition of "Risk Engineering" as: Identifying the potential for realization of unwanted, adverse consequences to human life, health, property, or the environment during the creative application of scientific principles to design or develop structures, machines, apparatus, or manufacturing processes, or works utilizing them singly or in combination to meet defined objectives by estimating the expected value of the conditional probability of the engineered product's impact to society, times the consequence of the product; or to construct or operate the same with full cognizance of the design; or to forecast the behavior under specific operating conditions; with respect to its intended function, economics of operation or safety to life and property, or other probability/statistical likelihood functions. Risk Engineering as a discipline acknowledges that uncertainty as a concept is unknowable and more importantly for engineering, indeterminate. Risk Engineering replaces this indeterminacy with the twin concepts of process variability and data/knowledge gaps for internal project risks and shareholder risk for those external acts, inclusive of the environment, whose actions/inactions create uncertainty about project delivery within constraints and assumptions. These are empirically observable phenomena and can be mathematically combined with documented past experience to produce estimates of future performance.

2.Develop a Theoretical Foundation for the Economics of Risk

Risk Engineering should be considered an extension of engineering economy into probabilistic engineering economy, given economics has been defined as a;

> *"…social science that analyzes the production, distribution, and consumption of goods and services… a primary textbook distinction …(within economics is) … microeconomics and macroeconomics."*[xi]

Normally, the emphasis at this diverges to microeconomics to examine …

> *"the behavior of basic elements in the economy, including individual agents (such as households and firms or as buyers and sellers) and markets, and their interactions."*[xii]

In the case of an engineering study, this definition translates to an examination of individual agents such as public agencies in various sectors of the economy and their market interaction; in this case, capital goods, construction and services sectors. While *"macroeconomics"* normally analyzes the entire economy and issues affecting it in an engineering context this becomes major sectors of the economy in terms of employment or specific subsets such as skilled craft labor or design talent. An engineering emphasis may look at international as well as domestic factors influencing growth or lack thereof, inflation, monetary and fiscal policy in the form of currency risk; financial markets as sources for capital; and regulatory risks for insurance labor management, just to name a few. The intent in this paper is not to present an all-inclusive checklist but only to outline a broad picture of how economics influences engineering and project management decisions.

Economics could be organized into financial and management accounting; our primary interest is the latter which has been identified as:

> *"Managerial economics …concerned with application of economic concepts and economic analysis to the problems of formulating rational managerial decision… and is a branch of economics that applies microeconomic analysis to decision methods of businesses or other management units. As such, it bridges economic theory and economics in practice."*

Engineering economics, also known as engineering economy, is a subset of economics for application to engineering projects. Engineers seek solutions to problems, and the economic viability of each potential solution is normally considered along with the technical aspects. Risk engineering and engineering economy are inseparable in this regard.

Still the authors emphasize the Role of an Actuarial based approach in Risk Forecasts. Trowbridge and Feldblum define an actuary as a *…"business professional who deals with the financial impact of risk and uncertainty. Actuaries provide expert assessments of financial security systems, with a focus on their complexity, their mathematics, and their mechanisms (Trowbridge 1989, p. 7)."* Additionally, *"Traditionally actuaries design and maintain products and systems and are involved in financial reporting of companies' assets and liabilities. In doing so, they must communicate complex concepts to clients who may not share their language or depth of knowledge. (Feldblum 2001, p. 8).*

Kaas writes in "Modern Actuarial Theory" (2001) that the very essence of the actuarial profession is to express preferences between future gains and losses. In this sense the risk professional should be able to fundamentally order risks as well as convey some idea as to the spread between the risks. Risk forecasts the necessity for an insurance company to price up an underwriting product, or for a public agency like the FTA to establish a baseline cost estimate on similar principles. The difference between and insurance company and the FTA is the amount of data or past experience that is available and how it can be organized and used for forecasting. Insurance companies have sufficient datasets to allow analysis on the basis of population groups. In developing a risk model first in 2001 and then again in 2005, the FTA did not have datasets to work with but rather individual projects and survivors; and on the basis as discussed below, constructed a "survivor" risk model that offered very robust risk forecasts.

Only later in 2006 with the release of Transit Cooperative Research Program (TCRP) G-06 and the FTA's own experience using detailed risk forecasts, was a data set assembled using "pooled risk models" that was sufficient to develop an actuarial basis for risk forecasts.

3.Risk as an Engineering Discipline

Risk analysis and management have evolved over the last thirty years from techniques to methods and finally into an empirical discipline comparable to the evolution of other engineering disciplines. This goes directly to support the objective of this paper to familiarize the reader in the development of their own framework for a transition as well as the associated attributes. Risk analysis and management in general are evolving disciplines. Risk analysis is empirically based, analytically driven, and capable of application and adding value in formally documented management systems.

As a technique, risk analysis could be defined as a non-specific approach to performing a task which may or may not result in an opinion that can be formally or informally delivered. As a method, risk analysis could be defined as a specific approach to performing a proscribed sequence of activities in a documented manner, resulting in an opinion that may or may not be transparent or reproducible.

Implicitly, any risk models used to support a programmatic decision to advance a project at a critical decision point, or specific funding level, represents a series of "policy" and "business" decisions by owner agencies and the grantee agency. The underlying business decision question is how much of the risk should be monetized and included in the budget and related contingency as well as how much financial capacity needs to be identified to handle the foreseeable risk exposure. This is the critical question, because a more robust risk forecast demonstrates that risk exposure could be larger than the budget and contingency arrayed before it; therefore it should be noted that:

- Risk exposure is almost always greater than the budget and contingency for a project.
- The difference between risk exposure and the project's budget and contingency is management's capability or capacity to manage and mitigate project risk.
- Management's capacity to manage and mitigate risk can be ad hoc or simplistic in the form of only "best practices", or defined with specific mitigation capacities, or integrated with risk informed decision making, or optimized with enterprise level risk management.

A common practice of using a "risk based" business model is defined in the following steps;

- Uncertainty is identified and modeled as a surrogate for reliability;
- Statistical Inference models generate a distribution based using judgments;
- The n^{th} percentile determines the "reliable" project budget (Year of Expenditure Dollars) inclusive of contingency.

Aside from questions of the validity of modeling and the adequacy of the rationale for n^{th} percentile thresholds, the model is relatively straightforward to implement and it is a very attractive concept. There are many approaches to analyzing project risk. One body starts by asking the following questions throughout the engineering planning phase: what could go wrong; what is the impact if it does go wrong; what are the associated consequences; what mitigation measures are available, and what resources are needed to meet the intended objectives? This catalog approach to assessing has had its limitations as discussed elsewhere in this paper.

Owner agencies such as the FTA have implemented this approach including the National Space and Aeronautics Administration (NASA), however, like the FTA, agencies have had the same experience namely: failed forecasts, poor mitigation structures, inability to incorporate programmatic experience, and an inability to perform tradeoffs to account for project specific conditions.

The authors, however, propose the use of variability modeling to efficiently define more than one variant of the project, and additionally modeling variability is fairly complex and variations must be described explicitly. The intention of variability modeling is to create and manage many variants of a project, and considering that mega projects cover multi disciple engineering fields and approaches, it becomes extremely important to address the uncertainties as variability models. The following steps to be counted for developing a Risk Informed Business Model:

- Model the uncertainty as a surrogate for reliability;
- Use Statistical Inference (SI) models to generate a distribution based using structured and calibrated judgments;
- Use SI models to simulate risk mitigation through project completion in a standardized framework;
- Overlay SI estimates with independent, deterministic estimates of project contingency;
- Independently develop several forms of risk mitigation;

- Use the SI modeling to identify a project "risk profile" using standardized risk decomposition process, incorporating programmatic experience with project specific data;
- Strategically integrate project contingency and mitigation capacities;
- Recognize that every project has unique conditions;
- Identify, analyze and compare risk profiles, mitigation strategies and contingencies to other projects.

This process should address the following questions throughout the planning, development and execution;

- How is this project different than others?
- What alternatives exist to execute the project?

The recommended procedure allows for tradeoffs between project elements such as risk profile, contingencies, mitigation capacities and the capability of the organization as well as a wider array of decision-making on what exactly is a "reliable" estimate of project capital cost for this project. Additionally the steps aforementioned should identify "gaps" between the optimized allocation and integration of resources, and the current allocation level, and it reveals areas that can be improved. The analysis must result in determining, documenting, and approving the variance between project requirements and current management capabilities.

The graduate level risk engineering program uses the following objectives as a means to achieve these goals: understand basic risk and probability concepts, model problems from a variety of management science methods, determine probability distributions from data or model dependencies, perform basic project controls based on project scope, and apply risk analysis and management techniques to engineering situations.

4. Role of Engineering and Policy Judgments in Risk (Risk Engineering, and policy judgment an Integrated Discipline that support project management)

The underlying premise of risk engineering is to identify risks and opportunities affecting project creation and development. Risk engineering provides value for project stakeholders. All projects face uncertainty; the challenge for management is to determine the acceptable amount of uncertainty. Uncertainty presents both risk and opportunity with the potential to erode or enhance value. The Nuclear Regulatory Commission (NRC) has recognized the lack of proper risk assessment in the context of hazard and life safety issues in project management by stating:

Scientific Policy Judgments in Risk Assessment states: *"The uncertainties inherent in project specific risk assessment can be grouped in two general categories: missing, biased or ambiguous information on a particular project process, component, constraint or assumption or "gaps" in current (project) management theory or practice"* therefore, adapting the NRC's statement about project management in the context of infrastructure projects requires a blending of scientific and policy considerations as part of a procedure or program that ensures that the judgments made in risk assessments and the underlying rationale for such judgments are made explicit.

The authors emphasize the understanding of the Role of Management Plans as a first frontier in developing a policy judgment in Project Management context. However, the role of management plans in supporting project management is not well defined [xiii] other than noting that there must be an overall management plan for executing all infrastructure projects.[xiv]

A project management plan (PMP) as defined by the FTA as a written document prepared and used by a grantee's organization inclusive of its project office and stakeholders[xv] which explicitly and adequately identifies the technical approach and all tasks necessary to define, deliver and commission (or start up) a major capital project within defined constraints and assumptions.[xvi] Until recently, no additional information or guidance was given on requirements for logical or hierarchical structures.[xvii] Therefore, no logical basis was provided for enhancing the capacity of management to mitigate risk since no requirement could be established in the form of a particular plan or sub-plan structure. The essential requirement for this structure of plans is that it represents an integrated entity. This integrated entity must completely and adequately define how the project organization will manage, monitor and control the project within its constraints. Thus, this integrated entity or structure of management plans must also demonstrate a hierarchy between the PMP, its sub-plans, and procedures which minimizes duplication. Figure 1 shows a proposed relationship between PMP and its sub-plans.

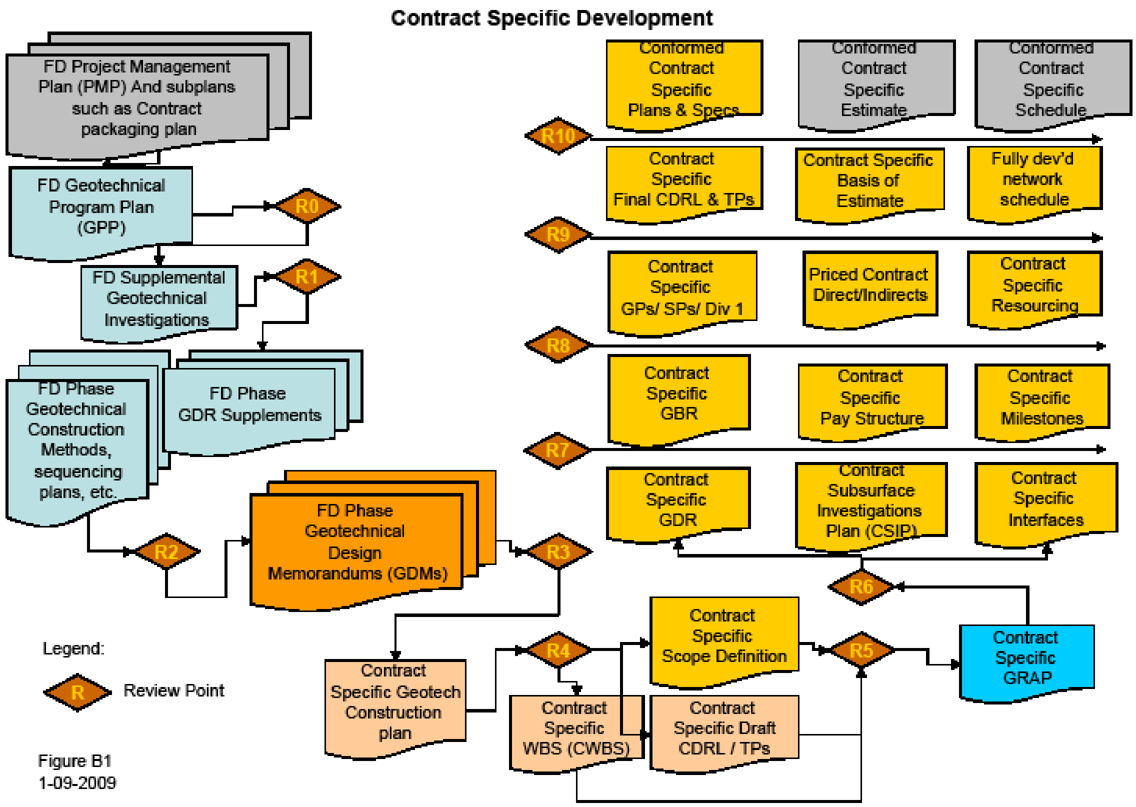

Figure 1: Proposed Relationship between PMP and sub-plans

It is important that the project management team establishes the strategic objectives of the project, and the risk management framework toward addressing the strategic (high level goals), operations (effectively and efficiently use of its resources), reporting (reliability of reporting), and compliance (compliance with laws and regulations); therefore, it is management responsibility to demonstrate its capacity and performance by articulating in a formally developed plan, a series of discrete tasks, allocated resources and responsibilities, and lastly constraints for scope, cost and schedule. Although, one of the key integration challenges in implementing these types of management plans is the lack of coordination between the PMP as a master document and its sub-plans. This is particularly difficult for some of the more specialized sub-plans such as the Cost Management Plan (CMP), or Schedule Management Plan (SMP).

These sub-plans also often demonstrate a lack of basis or an inability on the part of the project organization to control project budget and schedule.

To summarize the aforementioned structure;

- The PMP defines the major management processes and controls that ensure that the various management plan components work together;
- The PMP sub-plans describe how these processes and controls will be applied thru applicable procedures and
- The resultant deliverables or products that will be used to implement the project within its established constraints.

The students were required to create the Risk Management Plan portion of the PMP for the replacement of an existing bridge crossing a major waterway that included both a cost and schedule assessment.

Conclusion

Project stakeholder's and funding partners expect the project manager to execute and deliver the project in an effective and efficient manner. This paper presented an argument for the need to develop a risk engineering discipline. Risk engineering will address the challenges of inherent uncertainties in mega projects. The primary goal of risk engineering is to address the uncertainties associated with mega projects. The proposed method begins with introducing variability modeling to efficiently define more than one variant of the project. The authors also argued that each project is unique and modeling variability is fairly complex and variations must be described explicitly. The Project Management Plan (PMP) and its sub-plans are good documents to address model variability, and in these documents the project managers should refer to methods, tools and techniques for addressing project uncertainties. The intention of variability modeling discussed is to address inherent uncertainties in mega projects in an explicit and detailed manner. Additionally, it was argued that a complete gap analysis in the process of project execution will help owners to address the variance between project requirements and current capabilities.

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[i] US Department of Transportation, Federal Transit Administration (FTA), Federal Register, / Vol. 76, No. 177 / Tuesday, September 13, 2011 / Proposed Rules for Project Management Plans in 49CFR Section 633.03, page 56368, Section-by-Section Analysis, Section 633.3 Definitions.

[ii] American Society of Civil Engineers (ASCE), Civil Engineering Body of Knowledge for the 21st Century, 2008

[iii] Various business schools such as NYU Stern offer graduate degrees in "risk engineering", SwissRE offers "risk engineering" services, see www.riskengineering.com.

[iv] US Department of Defense, "Risk Management Guide For DOD Acquisition", Sixth Edition, (Version 1.0) ,August 2006, Preface

[v] US Dept of Energy, Project Management Practices, Risk Management (Rev E, June 2003), Section 1.0

[vi] US Department of Homeland Security, Risk Lexicon, 2010

[vii] Transportation Research Board, NHRCP report 658, Guidebook on Risk Analysis Tools and Management Practices to Control Transportation Project Costs, 2010, Section 3.3.1 Risk Analysis Terms

[viii] Project Management Institute, Body of Knowledge, 2004, Chapter 11, page 238

[ix] ISO/FDIS 31000:2009(E), Section 2

[xx] ASCE Body of Knowledge, 2008, page 6

[xi] Wikipedia contributors, "Economics," *Wikipedia, The Free Encyclopedia,* http://en.wikipedia.org/wiki/ Economics (accessed August 6, 2012).

[xii] Ibid

[xiii] This needs a supporting evidence quote such as the NAS studies on project management for DOE or Bureau of Reclamation…

[xiv] This needs to be qualified by noting ancillary attributes such as documentation, etc…

[xv] This definition has been upgraded from the original in FTA regulation and guidance. See below.

[xvi] US Department of Transportation, Federal Transit Administration (FTA) , the definition is condensed from that used by FTA for Project Management Plans in 49CFR Section 633.03 Definitions. States…

> "Project management plan means a written document prepared by a recipient that explicitly defines all tasks necessary to implement a major capital project."
>
> Accessed on July 19, 2011 from http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr;sid=4c8e8a9bfdb33c1d56e10649781cfcb2;rgn=div8;view=text;node=49%3A7.1.2.1.12.1.1.3;idno=49;cc=ecfr

[xvii] The Project Execution plan requirements discussed above on Page…, variously described requirement plans, mainly contingency management plans for cost and later schedule (in 2006 for NYCMTA's ESA, Hampton Roads, VA (HRT), Seattle WA ULink) and then later in 2009 with NJT's ARC project came explicit requirements for management subplans and design development specifics. MTACC's ESA and SAS FFGA amendments brought the development of the MTA Enterprise level PEP or ELPEP in 2010.